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Nat. History 2

AN ESSAY ON MAGNETISM:

OR AN Endeavour to explain the various Properties and Effects of the LOADSTONE: together with the CAUSES of the ſame.

Conſiderable effects may be caus'd by the unheeded motions of inviſible parts of matter, which are wont to be aſcribed to other leſs intelligible cauſes.

Boulton's epitomy of *Boyle*, vol. I. p. 235.

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AN ESSAY ON MAGNETISM.

INTRODUCTION.

WHEN men are once prejudic'd in favour of particular opinions, in any art or ſcience; notwithſtanding they are falſe; yet we have always found that it is with the utmoſt difficulty (though the inconſiſtency thereof is prov'd from the plaineſt demonſtrations) that they can be perſwaded to leave them; and this (if at all) is generally extorted by ſlow degrees. That this has been the Caſe, plainly appears from the great oppoſition made to Dr. *Harvey*, Mr. *Lock* &c. who, tho' they made very important diſcoveries, yet were contradicted by ſome, eſteem'd the greateſt men of that age; but ſtill we find, that truth did then, and always will, gain the aſcendant, tho' ſometimes but ſlowly. When any receiv'd

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ceiv'd *data* happen to be falſe, they certainly are ſome of the greateſt obſtructions to the improvement of knowledge in that art or ſcience in which they are received, and do fetter and lock up many important diſcoveries, which might otherwiſe be of the utmoſt Benefit. If, therefore, I ſhall be found to differ, from ſome received *data* in the following eſſay, I hope I ſhall not, *merely* on that account, be thought *deſerving* of cenſure, as my deſign in writing is no other than that it may give ſome aſſiſtance to the diſcovery of truth; and, I think, it the duty of every one to exert himſelf in the promotion of uſeful knowledge.

The chief thing, in the following eſſay, wherein I ſhall differ from ſome of the reigning principles in philoſophy, is in ſuppoſing, that the *ruling* or *moving agents* are *fluids* and *not ſolids*; and as the attraction of the loadſtone has been generally thought one of the moſt apparent inſtances of the *action of ſolids*, I ſhall endeavour to prove that the loadſtone is *abſolutely paſſive*, and that all the Effects of magnetiſm are perform'd by the extenſive and powerful actions of the incumbent fluids.

Had our philoſophers bent their thoughts this way, inſtead of aſcribing action to ſolids, we might long ago have had a much greater inſight into the cauſes of magnetiſm, than we have at preſent, and not have form'd *theories* contrary to ſome of the known laws of nature. As for example, it is, I believe, generally allow'd to be a law of nature, that matter cannot act but where it is preſent, and that in contact with the matter acted upon; and yet we find many, who believe that the loadſtone can and does act on bodies at a diſtance from it. — Others, whilſt they will not allow action to be perform'd by fluids, yet aſcribe the power of magnetiſm to what they call *magnetic effluvia*, which, I think, is giving up the point entirely, for it cannot be denied but that all *effluvia* are fluid.

That attraction is no other than a term for an *effect*, and not a *cauſe*, I have the Judgment of ſome of our greateſt philoſophers, and that this effect is perform'd by *impulſe*. Therefore notwithſtanding ſome of our preſent philoſophers may think it contradictory to *their* received opinions concerning it, yet as the great *Boyle* and Sr. *Iſ. Newton*, with many others have been of this opinion, on that account, this enquiry may not be deem'd uſeleſs, or unneceſſary.

Mr. *Boyle* gives the following account of attraction (ſee *Boulton*'s epitome, vol. 2. p. 235.) "attraction (ſays he) evidently appears to be a "ſpecies of *pulſion*, and ſuch an one as is uſually "term'd *truſion*, as when a gardiner drives his

“ wheelbarrow before him without letting go his “ hold.” I think this opinion of Mr. *Boyle* is laid down in too plain a manner to be miſunderſtood.

Graveſande ſpeaking of attraction deſcribes it thus (ſee *Graveſand*'s elements of philoſophy, vol. 1. p. 207.) “ We call this force *gravity*, “ (ſays he) when we conſider a body which of “ itſelf tends towards another; becauſe this force “ is called by this name near the earth's ſurface. “ But when we conſider a body towards which “ another tends, we call this force *attraction*; “ we mean the ſame *effect* by theſe names, and “ *nothing but the effect*. Again, p. 215. If gravity depends upon any known law of motion, it “ ought to be referr'd to a ſtroke from ſome extraneous body; and becauſe gravity is continual, a continual ſtroke would be required. If “ there be ſuch a ſort of matter continually ſtriking againſt bodies, it muſt of neceſſity, be “ fluid and very ſubtile, ſo as to penetrate all Bodies.” Here we ſee Mr. *Graveſande* tells us that by *attraction* he means *nothing but an effect*, and if it proceeds from any law of nature it muſt be from *impulſe*, and that this impulſe is performed by a *fluid* of a very ſubtile nature. And Sr. *Iſ. Newton* in his opticks, p. 351. gives his opinion of attraction in the following manner, *viz.* “ What I call attraction may be perform'd

" by *impulſe*, or by ſome other means unknown " to me. I uſe that word here to ſignify only in " general any force by which bodies tend to- " wards one another, whatſoever be the *cauſe*." Again, p. 325. when ſpeaking of the *cauſe* of gravity or the method by which the ſun and planets *attract* other bodies to them he has the following paragraph, *viz.* " Is not this medium " (æther) much rarer within the denſe bodies of " the ſun, ſtars, planets, and comets, than in " the *empty* celeſtial ſpaces between them? and " in paſſing from them to great diſtances, doth " it not grow denſer and denſer perpetually, and " thereby *cauſe* the *gravity* of thoſe great Bodies " towards each other, and of their *parts* towards " the Bodies; every body endeavouring to go " from the denſer parts of the medium towards " the rarer? For if this medium be rarer within " the ſun's body than at its ſurface, and rarer " there than at the hundredth Part of an inch " from its body, and rarer there than at the fiftieth part of an inch from its body, and rarer " there than at the orb of ſaturn, I ſee no reaſon " why the increaſe of denſity ſhould ſtop any " where, and not rather be continued through " all diſtances from the Sun to *ſaturn* and beyond. And though this increaſe of denſity " may at greater diſtances be exceeding ſlow,

"yet if the elaſtick force of this medium be ex-
"ceeding great, it may ſuffice to impel bodies
"from the denſer part of the medium towards
"the rarer, *with all that power* which we call
"gravity." Sr. *Iſ. Newton* in this laſt quotation tells us that not only the *attraction of coheſion* of the parts of bodies to themſelves, but alſo that the *attraction of gravitation* of one body to another is perform'd by what he calls *æther*. He alſo tells us that this æther *fills* all the celeſtial ſpace from the orb of the ſun to ſaturn and beyond it, and that attraction and gravitation are perform'd in the following manner, *viz.* that at the orb of the ſun, this *æther* is exquiſitely rare or ſubtile, ſtill growing denſer and denſer the farther it recedes from its body; and by the denſer parts preſſing continually into the rarer, every thing is forced along with it, *with all that power which we call gravity*.

There is another thing in this quotation from Sr. *Iſ. Newton* worthy the obſervation of ſome of our preſent philoſophers, *viz.* that he ſuppoſes the *whole celeſtial ſpace* between the ſun, ſtars, planets and comets to be *filled* with *æther*; and as this æther muſt be allow'd, in a philoſophical ſenſe, to be matter, as perfectly as gold or adamant, his opinion of a *vacuum* muſt be *only comparative*: and by *empty ſpace*, he means ſpace, empty in compariſon only, with other parts of ſpace which are fill'd with bodies of a more ſenſible reſiſtance. As for inſtance, ſuppoſe a bottle to be filled with water, if we pour out that water, we then ſay the bottle is empty, tho' it is then filled with air, as much as it was fill'd with water before; and, I believe, few will deny, but air is as much Matter, as water.

And this opinion of a comparative vacuum correſponds with the ſentiments of Mr. *Boyle*, for, ſays he, “we are to conſider the univerſe “that ſurrounds us, as a great *engine*, with no “vacuity, or no conſiderable one betwixt its “parts; and the actions of particular bodies, are “not to be eſtimated, as if two portions of mat-“ter of their bulk and figure, were placed in “ſome imaginary ſpace beyond the World, but “as ſituated in the World, as now conſtituted, “and their actions liable to be promoted, or “hindred, or modify'd by the action of other bo-“dies about them.” Again, p. 16. “The world “we live in is not a moveleſs, indigeſted maſs of “matter but αὐτόματον, or a ſelf-moving engine, “whoſe parts are moſt of them in a variety of “motions; and ſo cloſe ſet together, as to leave “no vacuities, or very little ones betwixt them.” And p. 364. he deſcribes a *vacuum* thus: “It “may be requiſite to advertiſe, that by *vacuities*, "I do not mean ſpaces *altogether void* of matter, "but void of *ſuch* as may be *perceived*; ſo that "I take the word *vacuum* in the *common*, not in "the *ſtrict* and *philoſophical* ſenſe of the word;" and in this ſenſe I wou'd be underſtood whenever I mention the word vacuum. See *Boulton's* epitome, vol. 1. p. 10.

If this is the caſe how abſurd are the notions of ſome of our philoſophers, in ſuppoſing a perfect vacuum in thoſe celeſtial ſpaces, and this, they ſay, becauſe their theory of the motion of the planets cannot be ſupported without it; but if a better, more ſimple and more natural account can be given of the actions of the planets and their cauſes, without a vacuum than with it, I hope thoſe philoſophers will not be unwilling to diſcard it, eſpecially as it is quite contradictory to the above quotation from Sr. *Iſ. Newton*. For if the celeſtial ſpaces are fill'd with *æther*, as Sr. *Iſ. Newton* imagines, and this æther, the farther it recedes from the ſun the denſer it grows; and this denſity increaſes in a regular manner from the body of the ſun to the utmoſt extent of the heavenly ſpaces, and all *motion* or *gravity* is cauſed by the denſer parts of this æther preſſing into the places poſſeſs'd by that which is rarer, we ſhall by this means be able to account for the motion of the planets, without their *ſuppoſed* vacuum, and that in a more intelligible manner. For if either by the action of the ſun, or the action of *light*, reflected from one planet to another, the æther or parts of the airs are divided, rarefied and made more ſubtile, on one ſide of the planet, whilſt the other ſide continues more denſe, then the conſequence that follows muſt be that the planet will be forced out of its place, by the preſſing in of the denſer æther or air, towards the ſide where the æther or airs are moſt rarefied and divided, and this motion muſt continue as long as the rarefaction is greater on one ſide than on the other; and the motion of that planet muſt be in proportion to the denſity on one ſide and the rarefaction on the other: For if God had thought proper that the rarefaction on one ſide of this terraqueous globe, ſhould have been as great again as it now is, and the force, with which the condens'd air preſſes in from the extremities, twice as great; I doubt not but it would have been turn'd round once in twelve hours, with as much eaſe as it now is in twenty four.

Now as it was the opinion of the great Sr. *Iſ. Newton* and Mr. *Boyle*, that the attraction and gravitation of bodies were perform'd by impulſe, and that, by a *fluid* call'd *æther* and not by the *ſolid parts* of the body itſelf, this, it is preſum'd,

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will be allow'd a ſufficient plea for diſſenting from the contrary opinion, though it may have been received by ſome great men ſince their time. And,

If this ſhould be found to be fact, *viz.* that the *acting* parts of this ſyſtem are the *fluids*, and not the *ſolids*; we may with great benefit as well as pleaſure extend our proſpect, and muſt imagine that the preſent account of the manner, by which the animal œconomy alſo (no impertinent ſubject but worthy of the cloſeſt attention) is carrried on, muſt be greatly defective, as the cauſe of the motion of the blood is aſcribed to the heart, which is a ſolid. And if action belongs to fluids *this* cannot perform what is aſcribed to it. We ſhall therefore perhaps after a ſtrict enquiry give a better account, without ſubſcribing to the doctrine of the Materialiſts, how, and by what means, the chyle aſcends from the guts to the ſubclavian veins, the preſent account ſeeming very inadequate to the power required; and, I doubt not, (were we to ſearch diligently, and that without prejudice,) but we ſhould ſoon be ſatisfied that the acting powers of the animal frame are in the fluids; the more ſubtile acting on thoſe of a denſer nature. If this ſhould be the caſe it ſeems very probable that we ſhall then be able to trace the riſe of ſome diſorders which at preſent are a little myſterious, and likewiſe underſtand better how ſome medicines act on the body. Why cooling, diluting, neutral, and opening medicines for the generality give moſt relief in inflammations and Fevers; whilſt on the contrary in moſt ſorts of palſies and other nervous diſorders, the greateſt relief is always found from thoſe that are warm, volatile, penetrating and corroborating. What may ſerve to give ſome weight to this opinion, and prove it to be ſomething more than the child of fancy is that although according to the preſent erroneous doctrine, the ſeveral motions of our body are generally aſcribed to the muſcles, (which are reckon'd amongſt the ſolids) yet from all the experiments hitherto try'd, we find, that by compreſſing, tying or cutting the nerves or arteries of theſe muſcles, and by that means preventing a ſupply of blood or nervous juice from flowing into them, their action immediately ceaſes. This ſeems ſufficient to inform us that the *cauſe* of action does not lie in the muſcles themſelves but in the fluids, which, however ſtrange it may ſeem, are the principal agents, and force their way by a natural impulſe.

AN ESSAY ON MAGNETISM.

IN order to underſtand what agent it is, that cauſes the *attraction* and *direction* of the *loadſtone*, it will be neceſſary firſt to obſerve, that as the *ſun* is nearer to a *perpendicular* over the *equator*, than over any other part of the *terraqueous globe*; ſo the *light* proceeding from it muſt *there*, meet with a greater *obſtruction*, and a greater quantity of it muſt be *reflected back* than at any other part; and of conſequence, there, the greateſt *rarefaction* or *expanſion* will be; and that *expanſion* will diffuſe itſelf towards each pole in *ſtreams of light*, and by that means produce a ſort of *vacuum*, on, and *towards* the *equator*; the ſeeming *deficiency* of which will be continually ſupplied with *air*, preſſing in from each *pole*, towards the *equator*, in the ſame manner as we ſee *air* does to any place where a *rarefaction* or *expanſion* is made, whether it be by fire, or by any other means which *divide* or *make ſmall* the particles of *air*; as I have prov'd in my treatiſe on electricity. And, whenever this happens, it muſt be occaſion'd by ſome *force*, as *motion*, *friction* &c. Which *motion* or *friction* being continued, and the particles of *light* being the *ſmalleſt*, they muſt cauſe the *leaſt* reſiſtance, and will therefore be ſent off by this *force*, and the *places* or *ſpaces* of thoſe particles of *light* be immediately ſupplied or fill'd up by the *groſs air*. — For, all experiments which have been yet tried, ſhew us, that *groſs air* is always endeavouring to *force* itſelf into the *places* or *ſpaces* where there is nothing but *light*; or wherever the *air* is *thinneſt* or compos'd of the *ſmalleſt particles*; and this *force* continues 'till the *air* in both *places* becomes of an uniformity. — This ſhews us the *cauſe* of all *winds*, and the *obſervations* on *winds* likewiſe prove to us, that this is the caſe. For, we find that the *winds* between the *tropicks* always blow from *eaſt to weſt*; and the *periodical* or *ſtated winds* blow from *land* to *ſea*, in the *morning*, and from *ſea* to *land*, in the *evening*.

The *cauſe* of thoſe *winds*, ſeems not to have been underſtood, 'till explain'd by the accurate Dr. *Halley*. For, no longer ago than the time of *Des Cartes* and *Rohault*, thoſe *winds* were accounted for, from the *rotation* of the *terraqueous globe*, which Dr. *Halley*, finding to be *erroneous*, from *experiments* and *obſervations*, lays down the following cauſe as a more *juſt* and *reaſonable* one —*viz.* "That, according to the *laws* of *ſtatics*, "the air, which is leſs *rarefied* or *expanded* by "*Heat*, and conſequently is more *ponderous*, muſt "have a *motion* towards thoſe *parts* thereof, which "are more *rarefied*, and *leſs ponderous*, to bring "it to an *equilibrium*; alſo the *preſence* of the *ſun* "continually *ſhifting* to the *weſtward*, that part "towards which the air tends, by reaſon of the "*rarefaction* made by his *greateſt meridian Heat*, "is with him carried *weſtward*; and, conſequently, the *tendency* of the whole body of the "*lower air* is *that way*.

"Thus a general eaſterly *wind* is form'd, "which being impreſs'd upon the air of a vaſt "ocean, the parts *impel* one the other, and ſo "keep moving 'till the next return of the *ſun*, "whereby ſo much of the *motion*, as was *loſt*, is "again *reſtored*; and thus the eaſterly *wind* is "made perpetual.

"From the ſame *principle* it follows, that
" this eaſterly *wind* ſhould, on the *north ſide* of
" the *equator*, be to the *northwards* of the *eaſt*,
" and in *ſouth latitudes*, to the *ſouthwards* thereof;
" for near the *line* the *air* is much more *rarefied*,
" than at a *greater diſtance* from it; becauſe the
" *ſun* is *twice* in a year *vertical* there; and at no
" time diſtant above 23½ degrees: at which times
" the *heat* being as the ſine of the angle of inci-
" dence, is but little ſhort of a *perpendicular ray*.
" Wherefore, the *air* towards the *northward*
" and *ſouthward*, being *leſs rarefied* than in the
" *middle*, it follows, that from both ſides, it ought
" to *tend* towards the *equator*.

"This *motion* compounded with the formerly
" *eaſterly wind*, accounts for all the *phænomena* of
" the general *trade-winds*, which if the whole
" ſurface of the globe was ſea, would undoubt-
" edly blow quite round the world, as they are
" found to do in the *Atlantic* and the *Ethiopic*
" oceans. — But ſeeing ſo great continents do in-
" terpoſe, and break the continuity of the oceans,
" regard muſt be had to the nature of the ſoil,
" and the poſition of the high mountains, which
" are the two principal cauſes of the variation of
" the wind from the former general rule: for
" if a country lying near the ſun prove to be flat,
" ſandy, and low land; ſuch as the deſarts of

" *Libya* are uſually reported to be; the *heat* oc-
" caſion'd by the *reflections* of the *ſun beams*, and
" the retention thereof in the ſand, is incredible
" to thoſe who have not felt it; whereby the *air*
" being exceedingly *rarefied*, it is neceſſary that
" the *cooler*, and more *denſe air*, ſhould *run* thi-
" therwards to *reſtore* the *equilibrium.* This is
" ſuppoſed to be the *cauſe*, why, near the coaſts
" of *Guinea*, the wind always ſets in upon land,
" blowing *weſterly* inſtead of *eaſterly*; there be-
" ing ſufficient reaſon to believe, that the inland
" parts of *Africa* are prodigiouſly *hot*, ſince the
" northern borders thereof were ſo very intem-
" perate, as to give the antients cauſe to conclude
" that all beyond the *tropics* was uninhabitable by
" *exceſs* of *heat*."

By the ſame rule we may eaſily account for the *periodical* or *ſtated winds* which *blow* from *ſea* to *land* in the *evening* and from *land* to *ſea* in the *morning*; for the *ſun beams* finding a greater *obſtruction* upon the land than upon the ſea, are thereby *reflected* in larger quantities, and by that means a greater *expanſion* or *rarefaction* is made on the land, than on the ſea; and of conſequence when the *ſun* has *acted* ſo long on the land as to cauſe a *greater rarefaction* there, than on the ſea; as is the caſe every afternoon, the more *denſe* or *groſs air* muſt be continually *preſſing* in from the ſea, 'till it comes to an *equilibrium* with it. As the above *theory* is ſufficiently proved from experience, and admitted by philoſophers of all denominations, it does not want any farther experiments to prove it. Now,

If the above explanation is true, (and as we are well aſſured that the *air* is *denſer* near the *poles* than on any other part of the globe, and likewiſe more *rarefied*, *divided* or *expanded* on the *equator* than any where elſe;) the conſequence that muſt follow, will be, a *continual* preſſing in of the *denſe* or *groſs air*, from the *poles*, to the *equator*; and an *expanſion* of the *light* from the *equator* towards each *pole*; and this in a greater degree than from and towards any other two places on the terraqueous globe; but *this* not being ſo perceiveable by our ſenſes as ſome other motions of the air may be, ſeems to have been the reaſon, why it has been ſo little attended to. As we find the greateſt *preſſure* of denſe *air* muſt be *from* each *pole*, ſo the greateſt *rarefaction* or *expanſion* muſt be from the *equator* towards each *pole*; but as the *denſity* near the *poles* and the *rarefaction* on the *equator* undergoe very little *Alteration*, and are always *nearly* the ſame, ſo the Wind proceeding therefrom muſt make an almoſt imperceptible difference as to us; for the *rarefaction* or *expanſion* at and from the *equa-*

tor is of a proper *ſtrength* to *ſupport*, *divide*, *break to pieces*, and ſo *deſtroy* the *denſity* of the *air* coming from *each pole*, and, as I obſerv'd before, the motion or wind of the airs muſt be little or not at all perceiv'd; for, as the ſtrength of all winds is, in proportion to the *ſuddenneſs* and *greatneſs* of the *rarefaction* in compariſon with the *denſity* of the ſurrounding *air*, ſo, whereever the ſurrounding *air* is *moſt denſe* and the *rarefaction* or *expanſion* the *greateſt*, and *moſt ſudden*, there the wind or motion of the airs will be the moſt violent and ſtrongeſt, as is prov'd by all experiments on *gunpowder*; and where the *expanſion* or *rarefaction* is the *leaſt*, or comes on in the *moſt ſlow equable manner* there it will be the *leaſt perceiv'd*.

The *preſſure* of the *air* form the *poles* to the *equator*, and the *expanſion* from the *equator* to each *pole* being prov'd; I hope I ſhall with eaſe be able to account for all the *phænomena* of *magnetiſm* upon the above principles.

Since it follows, from what has been ſaid, that there muſt be a *continual* or *uninterrupted current* of *air* paſſing from each *pole* to the *equator*, and a *perpetual ſucceſſion* of ſtreams of *light* from the *equator* to each *pole*; and ſince it is agreed that the loadſtone is compos'd of different *laminæ* which run in a *direct line* from one end of the ſtone to the other, and that the *pores* in the parts which compoſe the *ſides* of theſe *laminæ*, are impenetrable by *light* in *particles* of the ſame ſize with thoſe which paſs thro' the *interſtices between* the *laminæ* of the *ſtone:* from this form, I ſay, we may eaſily imagine, that the *current* of *light* or *æther* going from the *equator* (which is in much the *ſmalleſt* particles) gains entrance at the north end of the loadſtone [a]: the particles of air coming from the equator to each pole are of different ſizes, and then as the loadſtone from the ſmallneſs of it's pores admits nothing thro' it but *light*, the remaining *particles* of the *air* will be *forced* off on each *ſide* of the *loadſtone*, by the ſucceeding *current* of *light* and *air*, in the ſame manner as *water* is through the *arches* of a *bridge*; where we ſee that after the middle arch, where the ſtream is the ſtrongeſt, has admitted as much of the water as it can contain, the *remainder* is *turn'd off* on *each ſide*; ſo, the *loadſtone* admitting nothing but *particles* of *light*, the *remainder* of the *air* (which is *too large* to *paſs* the *pores* of the *loadſtone*,) is forc'd off on each ſide of it, by the following *current* of *air*; and

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[a] The *end* of the *loadſtone* that *points* towards the *ſouth*, is, by the generality of writers, call'd the *north end* or *pole*; and that pointing towards the *north end* is call'd the *ſouth pole*; for which reaſon whenever either is mention'd I would be always underſtood in that manner.

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it muſt neceſſarily happen that the loadſtone or magnetic needle, when hung at liberty, will point north and ſouth; for this current of *light* ſtriking againſt its ſuperficies, and not being able to enter the loadſtone or needle in that direction, it muſt cauſe an alteration in its ſituation 'till the length of its pores coincide with the direction of the above current. For as Dr. *Halley* has obſerved, whereever one *part* of the *air* is *thinner* or *finer* than the reſt, (as has alſo been proved by all ſtatical experiments) the *groſs* or more *denſe air* is *continually* endeavouring to *preſs* itſelf into that *vacuum* or *place* poſſeſs'd by the *æther* or the *more fine* and *ſubtile parts of the air*; and as it has been ſhewn that the loadſtone *admits* nothing but *æther* or *light*, ſo by that means, a *vacuum* is made, and the *air* is continually *preſſing* itſelf towards that *vacuum*; and in *proportion* to the *quantity* of *æther* or *light* that paſſeth in *ſtrait lines*, from *end* to *end* thro' the loadſtone, in ſuch proportion its *magnetical power* muſt be. By which we find that only the *finer parts* of the *air paſs* the *loadſtone*, and they in *ſtrait lines thro' the ſtone:* ſo, by the *make* and *diſpoſition* of the *parts* of the *loadſtone* we ſee that it muſt be *turn'd* from the *pole* to the *equator*, in the ſame *manner* as a *weather cock* is by the *wind*, with this difference, that the *ſtrength* of the *wind* muſt be much more *variable* than this *æther*, which varies but very little.

From the plain and eaſy deſcription already given of magnetiſm, we find that the continual *current* of *light* or *æther thro'* the *ſtone*, acts much *in the ſame manner* as *air* does, that is *forced up* a *chimney*, or thro' other *narrow paſſages*, where we ſay there is a *draught* of *air*; and whenever *iron* or *ſteel* are within that *draught*, the *current* of *air*, following it, drives it to the *loadſtone*; as we obſerve a piece of *paper*, *linnen* or other *light matter* is *forced* up a chimney, by the ſucceeding current of air.

The reaſon why *iron* or *ſteel* is the thing that the *loadſtone attracts*, is becauſe the *iron* is compoſed of matter that hath the ſame kind of *pores* and of the *ſame ſize* with thoſe of the *loadſtone*, which are *filled* with particles of *light* or *æther* of the ſame *ſize* or *kind*; for which reaſon, whenever is is placed *within* the *current of light* or *finer parts* of the *air*, which paſs *thro'* the *loadſtone*, it is immediately *puſh'd* to it by the *ſucceeding current*, unleſs the *number* of the particles of *iron* be *ſo great*, that, by their *weight*, they are able to *withſtand* the above *current* and *turn it aſide*.

The reaſon why nothing but *iron* or *ſteel* are *puſh'd* to the *loadſtone*, is becauſe the *pores* of other bodies are of an improper *make* or *ſize*, to *admit* in the ſame manner and *retain* particles of *light* or *æther* of the *above ſize*; their *pores* being generally *diſpers'd* after the ſame ſort as the *pores* are in a *ſponge*, or in a *ball* of *ſand*, by which means, as ſoon as it is *admitted* at ſome *pores* it is immediately *diſcharg'd* at *others*, and not confined to, or continued in a ſtrait line.

In making *artificial magnets* there is always given them a *greater power* of *magnetiſm* than *they can retain* any conſiderable time; for be it much or little it continues to *loſe* this *additional power* 'till it comes to a proper ſtandard for the *quantity*, *make*, and *goodneſs* of the artificial magnet to *contain*; for if artificial magnets are deſign'd to be of a *great ſtrength* they muſt be made of *ſteel bars* of a proper *length* and ſufficient *hardneſs*; it being impoſſible to make the *ſtrongeſt* artificial magnets of *bars* either *too ſhort* or *too ſoft*. This additional power is certainly occaſion'd by the *application* of the *magnet* which touch'd it; for on its *removal* it continues to *loſe* more and more till it comes to its proper ſtandard.

This ſeems to give us a great inſight into the *cauſe* of magnetiſm; for on the *application* of the *magnet* to a *bar* of *ſteel*, a *larger quantity* of that ſubtile part of the air or æther is *forc'd* to that place; for, as the *air within* the *magnet* is much more *ſubtile* or *fine* than the *air without*, ſo this *æther* or *finer part* of the *air* is immediately *forc'd* through the *magnet* by the *groſſer air* without; which, as has been before obſerv'd, is *continually endeavouring* to make its way or intrude itſelf into every Place where the *air* is *more fine* or *ſubtile*, and according to the *ſtrength* and *power* of the *loadſtone*, in *ſuch a quantity* this *ſubtile part* of the *air* will be *forc'd* thro' the *bar*. — This *æther* or *finer part* of the *air paſſing the loadſtone*, of conſequence, makes a ſort of *vacuum* behind it, and as the *air* is *continually endeavouring* to *preſs* into any part wherein is contain'd *air* of a *different denſity* or *fluidity*, ſo the ſurrounding *air preſſing* towards the ſtone, *forces* this moſt *ſubtile part* continually *thro'* it, and the *remaining part* is turn'd off on each ſide.

The *greater* the *quantity* of this ſubtile fluid or æther is that *paſſes* the ſtone or ſteel, with the *greater force* the groſs air preſſeth towards it, in the ſame manner as *air* does into *a fire*. For,

As it is commonly expreſs'd, a *large fire draws* much more *air*, and *faſter*, than a *ſmall one*; ſo here a ſtrong loadſtone, thro' which *paſſeth* a large quantity of this *æther* or *light*, muſt *draw* more than a *weak one* that has but a *ſmall quantity of æther or light paſſing* thro' it, *cæteris paribus*, in proportion to the *denſity* of the ſurrounding *air*.

So, here we find, when we are making a piece of ſteel magnetical, the *large* quantity of this *æther* or *light paſſing* through the *loadſtone* as well as thro' the *ſteel*, it muſt follow, that this *current* of *air* will then *act* with *greater force*, than it can after the *loadſtone* is *removed*; from which we may conclude, that as ſoon as the *loadſtone* is *remov'd*, the *force* of *this current* of *air* is *continually leſſening*, 'till it comes to a *due quality* to *paſs* this piece of *ſteel made magnetical*; and this in the *ſame manner* as *fire* does in a *chimney*; for make a *large fire* and the *air* will *preſs in largely*, but *remove* the *greateſt quantity* of that *fire*, and then the preſſing in of the *air* will *continually leſſen*, 'till it comes to a proper quantity *to ſupport* that *fire* only.

And that the *attraction* of the loadſtone is not cauſed from any *magnetical effluvia*, or *part* of the *very ſubſtance* of the ſtone, continually *flying off* from it, (as has been generally imagined) may with eaſe be prov'd, beyond contradiction; for, was this the caſe, whenever a *ſteel bar* is *made magnetical*, the *loadſtone* muſt *loſe* ſome of *its weight* and the *ſteel bar* receive an *addition* to *its weight*, but we find juſt the contrary to this happens; the *loadſtone* continues the *ſame* and the *ſteel bar* inſtead of *gaining*, *loſes part* of its own *weight*. We alſo find by experiments, that we can *give* a *ſteel bar* a *power* of magnetiſm *ſtronger* or *weaker* in proportion to its *hardneſs*, and to the *force* with which this *æther* is *puſh'd* thro' it, by being *touch'd* with another *loadſtone*; and, we alſo find, that where a *loadſtone* is *not to be had*, yet the *magnetical power* is eaſily given it, by *ſtroking it* in a *ſtrait direction* with a *piece* of *iron* only. — Which proves to a Demonſtration, that this *magnetical power* proceeds from the *current* of *air*, *forcing* the *æther* in *ſtrait lines* thro' its *length*, and not from any *magnetical effluvia* or *power inherent* in the *loadſtone*. For we find that thoſe ſteel bars are made *magnetical* and the *light* or *æther* is *forc'd* thro' them by the *motion* of an *iron bar* on them, much in the ſame manner as by the *motion* of *your hand*, or any other *body*, being drawn in a *ſtrait line*, thro' any quantity of *water*, a *current* is made; and if there are any *light bodies* ſwiming on the *water* near it, they are *forc'd* directly after your *hand*, in the following current. If the *attraction* of the loadſtone is perform'd as above deſcrib'd, we muſt imagine, (as the caſe really is) that whenever a *loadſtone* is *hung at liberty* in the *air*, it muſt immediately *turn* its *north pole* towards the ſouth, and its *ſouth pole* towards the *north*; and that there muſt be a *declination* or variation in its *poles*. — For, as the *earth's annual courſe* thro' the *ecliptic* is not directly with the *equator towards the ſun*, but one half of the year on one ſide of it, and the other half year on the other ſide; ſo, of conſequence the *rarefaction* or *expanſion* muſt be greater in ſome places on one ſide of the line than it is on the other ſide of an equal diſtance from it; by which it muſt follow, that one pole of a *loadſtone* muſt always *point* towards the *place* where the greateſt *rarefaction* or *expanſion* is made; which in ſome parts of the world may vary very much from the true *north* and *ſouth poles* of it; and that this variation may be alſo greater at ſome times than at others.

This account being given, I think, we may form a very clear idea how and by what means the variation of the loadſtone is performed, as well as its direction. By this we alſo ſee the reaſon why Dr. *Gilbert* and others attributed the variation of the loadſtone "to the earth or conti-
" nents of land drawing the needle out of its
" meridian direction, and that it varied more, or
" leſs, as it was more or leſs diſtant from any
" great continent. Conſequently, that if it were
" placed

" placed in the middle of an ocean, equally diſ-
" tant from equal tracts of land, on each ſide
" eaſtward and weſtward, it would not decline
" either to the one or to the other." This is a fact that holds good in the general, but is not without its exceptions, and may be eaſily accounted for as above, viz. that the needle's inclining towards the land or continent is occaſion'd by the land reflecting a greater number of the ſun beams, and thereby making a greater rarefaction thereon than on the ſea; by which means the above current is turned out of its courſe that way.

Dr. *Halley* finding that this did not hold univerſally true, formed the following hypotheſis, viz. " That the whole globe of the earth is one
" great magnet, having four magnetical poles,
" or points of attraction; near each pole of the
" equator two; that thoſe parts of the world
" which lie nearly adjacent to any one of theſe
" magnetical poles, the needle is governed there-
" by; the neareſt pole being always predomi-
" nant over the more remote." And to make this hypotheſis conſonant to experience, he alſo ſuppoſed thoſe four magnetical poles to belong to two ſeperate globes, viz. that this globe of earth contains within it an internal globe or nucleus, two of which poles belong to the outward

globe and two to the internal or nucleus. Now when we come to conſider that the equator is interſected twice in the year, and at two different places by the ecliptic, we muſt be aſſured that on and towards theſe places there muſt be a greater rarefaction than any where elſe, and if the direction of the needle is as above deſcribed, we cannot help thinking that, in many places of the earth this muſt cauſe very conſiderable variations; and we find from Dr. *Halley*'s account that thoſe variations are entirely agreeable to the above ſimple and plain theory, without being at the trouble of ſearching after attracting poles to this terraqueous globe, when at the ſame time we have no foundation for ſuch an imagination; and the account given by Mr. *Boyle* (ſee *Boulton*'s epitome, vol. 3. p. 36.) that it was obſerved by a perſon who ſail'd on the coaſt of *Greenland*, "that he there met pieces of ice 50 fathom "deep, which were not above a tenth part un-"der water. He likewiſe obſerved the variation "of the compaſs to be 22 Degrees; and a little "time after; ſcarce any thing at all. And it is "obſerved, that theſe mountains of ice much "weaken the ſtrength of winds, inſomuch that "if they be driven near them by a ſtorm, that "the wind is ſo much quaſh'd that they imme-"diately find a calm." This experiment or obſervation not only confirms what is above advanced, that wind is cauſed as above deſcribed, but alſo that the direction of the needle is from the ſame cauſe; for here we find the intenſeneſs of the cold air proceeding from the mountains of ice, cauſed an alteration both in the wind and the direction of the needle.

As the above theory accounts for the variation of the magnetic needle in ſo eaſy and natural a way, let us try whether it won't do the ſame for its inclination or dipping. From a great number of experiments it is certain that the needle under the line is exactly parallel to the horizon, and the farther you go from the line it inclines more and more towards the earth 'till you come near the pole, when inſtead of pointing north and ſouth, it pointed *perpendicular* to the *horizon*, and *turned indifferently* to all parts of the heavens. "This was found to be true by "ſome *Dutch* pilots who attempted to find a "north paſſage into the *Eaſt-Indies*. It has alſo "been obſerved by pilots, that as the needle has "no inclination or dipping under the line, ſo to "thoſe who live in the ſouthern parts of the "earth, it inclines the contrary way to what it "does in the northern parts; for when they had "ſo order'd the paſte-boards of their compaſſes "in which the needles were incloſed, that they "might hang in equilibrio upon their points, before they were touch'd upon the loadſtone; "and when they had put pieces of wax upon "the ends of the paſte-boards which look'd towards the ſouth, to hinder the needles from "inclining after they were touch'd in order to "preſerve this equilibrium they have been forced to take off theſe pieces of wax by degrees "as they drew nearer to the equinoxial line, and "to put them on them other ſide of the paſteboard as they went ſouthward of the line. All "which is a certain ſign, that without this wax, "the needle would have the inclination, which "we have mention'd above." See *Rohault*'s ſyſtem of natural philoſophy, part 3. chap. 8. ſect. 22.

Now as we have before ſuppoſed the direction of the needle to be always in a direct line made by the current of air preſſing in from the fartheſt and moſt remote parts of this terraqueous globe towards the equator, or where the greateſt rarefaction and expanſion is made by the action of the ſun thereon, ſo if the cauſe of this direction of the needle is as has been above deſcribed, it muſt dip or incline towards the horizon differently in different places, and that in the ſame manner as we find it does from obſervations and experiments.

From what has been ſaid may eaſily be obſerv'd alſo, the reaſon, why if a loadſtone be cut in ever ſo many *pieces*, each *piece* has its *poles*, and points *north* and *ſouth*.

We find that upon *touching* an iron needle with a loadſtone, it will *communicate* to it, the *power* of *attraction*, and likewiſe if poiſed in the air, it will *direct* its poles one towards the north and the other towards the ſouth, by which we may imagine that the iron is compoſed of different laminæ, in the ſame manner as the loadſtone, and that theſe laminæ have ſome ſmall *obſtructions* between them that hinder the above deſcribed *current* of *æther* from *paſſing* directly thro' them, and that thoſe obſtructions *continue* 'till they are ſcour'd thro', and cleans'd by ſome *force* from without the iron; as by continuing the bar of iron for a long time in a north and ſouth direction, by placing the iron in a perpendicular poſture, and keeping it a long time in that poſition, by which means the *light* proceeding from the *ſun* being *puſh'd* with a great force towards the earth, enters between thoſe laminæ of the iron, and by the ſun's acting continually in the above manner, by degrees, forces thro' thoſe obſtructions and gets a free paſſage for the *light* or *æther* in *ſtrait lines* from end to end, or by a loadſtone being applied to the iron.

For as the *light* or *æther* paſſeth thro' the loadſtone with great force, ſo when its end is applied to the iron the *light* or *æther* proceeding therefrom forces its way thro' the iron; the light ſent thro' the loadſtone acting in the ſame manner as air when forced out thro' the noſe of a pair of bellows, by which additional force it breaks down and puſhes before it thoſe ſmall obſtructions; after which, its pores being *form'd* in the *ſame manner* as the pores of the loadſtone, it muſt have the ſame effect.

Hence it appears that we have no occaſion to attribute to the loadſtone a *ſoul* to animate it, as ſome of the *antients* did, nor with moſt of the *moderns*, to allow it, to have a power of *attraction innate in it*; for which purpoſe they have laid down rules quite contradictory to each other, viz. that all matter is inactive, and yet at the ſame time it is allow'd to have power inherent in it to *attract* or *gravitate*.

That the loadſtone acts as above deſcrib'd and likewiſe that it communicates its power to *iron*, *ſteel*, in the above manner, ſeems to be greatly confirm'd by ſome *experiments* of Mr. *Whiſton*'s, which are, that needles after touching *weighed* conſiderably *leſs* than they did before; for having weigh'd two needles *before* they were *touch'd*, one weigh'd 4584⅛ grains, the other 65726 grains, and on weighing them again *after touching*, he found the firſt *loſt* 2$\frac{5}{8}$ grains, and the other *no leſs than* 14 *grains*, which *loſs* may eaſily be accounted for as above, viz. that the *light* or *æther* being *puſh'd* with great force, from the loadſtone *thro' the iron*, it *breaks down* the ſmall *obſtructions* between the laminæ of the iron and drives them off. This ſeems to be the very caſe: for on making an artificial magnet, if before you touch it, you wipe it as clean as you can; after it has been touch'd you will find, at each end of ſuch artificial magnets, ſome parts of the ſteel in an impalpable powder; this impalpable powder ſeems to be forced from the ſteel bar by the loadſtone acting as above deſcribed. Mr. *Whiſton* could not, or at leaſt *does not give us any reaſon for the above loſs of weight*. —From what has been ſaid we ſhall be able to account for all the *phænomena* of the *loadſtone* with eaſe, moſt of which I ſhall give, with the means by which they are produced; without being at the trouble to form theories contrary to nature; as I imagine the theory to be which is now generally received, viz. that a great many of its *phænomena* are cauſed by a *vaſt ſpherical loadſtone* within this terraqueous globe. — I doubt not but this *vaſt ſpherical loadſtone* is in fact a *non-entity* and not to be found any where, but in the imagination of thoſe philoſophers; yet we find it has been laid down as an almoſt demonſtrative certainty, and they go ſo far as to give us its nature, make, motion, the places where its poles are to be found, and the ſize of it to ſuch a nicety, as to tell us that its diameter is about eleven hundred and fifty miles. This is only endeavouring to account for one difficulty by raiſing another which is greater; for, in the firſt place, it is contrary to all the known rules of nature, for matter to act in places where it is not, as this *vaſt ſpherical loadſtone* is ſuppoſed to do, for they make it to act without this globe, though its ſituation be a great many hundred miles within it. In the next place, (this being allow'd) if theſe philoſophers were aſk'd how, and by what means this *vaſt ſpherical loadſtone* has its power, and acts, I imagine, they will be at as great a loſs in accounting for it, as they were before in accounting for the power of our common magnets.

An account of moſt of the properties and effects of the loadſtone has already been given; but as, I imagine, a great many that may read the foregoing eſſay would be willing to know whether the above theory will explain all the experiments that have been yet try'd on magnetiſm, or not, I ſhall for their farther ſatisfaction, recite all I have met with; and, if on a recital, I meet with any that have not been thoroughly accounted for, by what has been already ſaid, I will endeavour to make them more clear when they are recited.

1. "In every magnet there are two poles, one "whereof points northward, and the other ſouth-"ward, and if the magnet is divided in ever ſo "many pieces, the two poles will be found in "each."

2. "The poles in different parts of this terra-"queous globe are differently inclined towards a "point under the horizon." This is called dipping.

3. "If two magnets be ſpherical, one will "turn or conform itſelf to the other; and after "they have ſo conform'd or turn'd themſelves, "they will endeavour to approach or join each "other; but if plac'd in a contrary poſition, they "will avoid each other."

4. "If a magnet be cut quite through accord-"ing to its length, the parts or ſegments of the "ſtone, which before were join'd, will now a-"void and fly each other."

5. "If a magnet be cut quite acroſs, the two "points, which before were conjoined, will be-"come contrary poles; one in one and the other "in the other ſegment."

6. "Iron receives virtue from the magnet by "application to it, though it doth not touch it, "barely from an approach near thereto; and the "iron receives this virtue variouſly according to "the parts of the ſtone it is made to touch, or "even to approach to."

7. "Steel receives virtue from the magnet better "than iron."

8. "If an oblong piece of iron be any way applied "to the ſtone, it receives virtue from it, "only as to its length."

9. "The magnet loſeth none of its own virtue "by communicating any to iron; and this "virtue it can communicate very ſpeedily; tho' "the longer the iron touches or joins the ſtone, "the longer will its communicated virtue remain "in it; and a better magnet will communicate "more of it, and ſooner than one not ſo good."

10. "Needles diminiſh in weight on being "touch'd, but the magnet remains the ſame."

11. "A needle touch'd by a magnet will turn "its ends the ſame way towards the poles of the "world, as the magnet itſelf does, and all magnets "and needles have the ſame direction, if "hung at liberty in the ſame place, at one and "the ſame time."

12. "Neither loadſtone nor needles touch'd "by it do conform their poles exactly to thoſe

" of the world, but have uſually ſome variation " from them: and this variation is different in " different places, and at divers times in the ſame " place."

13. " In theſe northern parts of the world the " ſouth pole of the loadſtone will raiſe up more " weight of iron than the north." It is the denſe air coming from the pole which forces the iron towards the loadſtone, and this is the reaſon why the pole which points that way will raiſe a greater weight than the north pole.

14. " The force of the loadſtone is variouſly " increas'd or leſſen'd by the various application " of iron or another loadſtone."

15. " A Plate of iron only, but no other body interpoſed, can impede the operation of the " loadſtone." The reaſon of which is, that as ſoon as the *light* or *æther* which paſſeth thro' the loadſtone arrives at the plate of iron it is directed by the *laminæ* of the plate to its out ſides, and there emitted, and does not paſs in a direct line thro' the plate, it being hindred by the laminæ of the plate being placed in a quite different direction.

16. " The power or virtue of the loadſtone " may be impar'd by lying long in a wrong po- " ſition, as alſo by ruſt, wet, &c. and it may be " quite deſtroy'd by fire." As we find fire has a

power of penetrating all bodies in all directions, it is no wonder it ſhould, by that means, deſtroy the attracting power of the loadſtone as above deſcrib'd.

17. "Bending a piece of iron wire that has "been touch'd deſtroys its directive virtue." This muſt be eaſily imagined to be the caſe by breaking, deſtroying and ſo filling up thoſe ſtrait and hollow interſtices or channels between its *laminæ*.

18. "The ſphere of activity of magnets is "greater or leſſer at different times."

19. "A ſmall fragment of a loadſtone will "change its poles, by being applied to the oppo-"ſite pole of a large vigorous loadſtone."

20. "The iron bars of a window &c. which "have a long time ſtood in an erect poſition, "grow permanently magnetical, the lower end "of ſuch bars being the north pole, and the up-"per the ſouthern."

21. "A bar of iron that has not ſtood long "enough in an erect poſture, if it be only held "perpendicularly any time, will become mag-"netical, and its lower end the north pole; as "it appears from its attracting the ſouth pole of "the needle: but then this virtue is tranſient, "and, by inverting the bar the poles will ſhift "places. In order therefore to render the quali-

" ty permanent in the iron bar, it muſt continue " a long time in a proper poſition; but the fire " will produce this effect in a ſhort time: for as " it will immediately deprive a loadſtone of its " attractive virtue; ſo, it ſoon gives a verticity to " the bar of iron, if, being heated red hot, it be " cooled in a direct poſture, or directly north " and ſouth."

22. " A needle well touch'd will point north " and ſouth: if it have one contrary touch of " the ſtone, it will be deprived of its faculty; " and by another ſuch touch it will have its poles " quite changed from ſouth to north."

23. " If a bar of iron has gain'd a verticity by " being heated red hot and cooled again north " and ſouth, and then hammer'd at the two ends, " its virtue will be deſtroy'd by two or three " ſmart blows in the middle."

24. " A magnet acts in *vacuo* as well as in the " open air." As we have found from experiments that gravity acts in *vacuo*, ſo we muſt imagine the loadſtone will do the ſame, both theſe effects proceeding from the ſame cauſe; for, (as was obſerved in the *introduction*,) what we call a *vacuum* muſt be conſider'd as being ſo only in a comparative degree. By endeavouring to make a *vacuum* the moſt we can do is little more than extracting the atmoſphere or groſſer

parts of the air; as the finer parts of the air paſs thro' the glaſs with as much eaſe as water does thro' a ſieve, ſo, were it poſſible to extract any of it by the pump, as faſt as it was drawn out by the action of the pump it would again enter thro' the pores of the glaſs, and as long as this fluid remain'd within the glaſs, ſo long *gravity* and *magnetiſm* muſt act; and tho' ſome of the denſer parts of the air may be extracted and thereby that force by which gravity acts will be leſſen'd, yet as the reſiſtance is leſſen'd in proportion, the effect will be the ſame.

These being all the phænomena, worthy of notice, I have yet met with concerning the qualities of the loadſtone, and as they are not only eaſily accounted for by the above theory, but are alſo great confirmations that this theory is true, ſo, I imagine, whatever others belong to it they will be eaſily explain'd from the above principles.

FINIS.